Chaos, Complexity and the Battlefield

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THE CONCEPTS OF CHAOS and chaotic systems, once sole concerns of the mathematician, have found a place in a variety of other professions as well. A growing body of literature applies the insights of chaos theory to a variety of fields, including organizational behavior and military science. In fact, an entire web page is dedicated to the application of chaos and complexity theories to Clausewitz's works.[1] The US Marine Corps even mentions chaos theory in Doctrinal Publication 6, *Command and Control.*[2] This article aims to render chaos theory accessible without trivializing it, so that Army officers can better grasp and apply the insights offered by chaos theory and better understand their own profession. In Doctrinal Publication 6, a fictional general tells his staff that chaos theory means they must remain flexible.[3] Even a qualitative understanding of chaos theory can tell us much more than that.

To reduce confusion on the battlefield, the Army has developed better and more sophisticated information gathering and processing technologies. However, applying these technologies increases the complexity of the battlefield and thereby increases the likelihood of chaotic behavior—all of which increases confusion. Understanding this process will give Army officers an advantage they do not currently have. Military leaders who methodically apply chaos theory can develop policies and doctrines that can help them deal better with the unexpected events and circumstances that increasingly characterize the modern battlefield.

Several times in recent years, the United States and its allies have applied military force with unexpected results. During the Gulf War, coalition forces routed an enemy that was roughly equal in terms of numbers and equipment. While the coalition expected victory, it also expected tens of thousands of friendly casualties. Instead, there were less than two hundred. In Somalia, a technologically disadvantaged gang leader took on the world's only remaining superpower, surprised military planners and won. These events caught off guard those who no longer properly understand the nature of the battlefield. Since the beginning of World War II, the battlefield has become increasingly complex and, consequently, much more unpredictable.

The Battlefield as a Chaotic System

The first step in applying chaos theory to the modern battlefield is to establish that it is indeed a chaotic system. If unexpected events are the results of random chance, then applying chaos theory will offer little insight. Chaotic systems are not random systems, and thus their outcomes are not accidental, but rather the result of complex interaction among the system's components. While these outcomes are usually impossible to predict, the process that yields them is not impossible to understand.[4] In a random system, at some level at least, there is no process to understand. If battle is no more than a random process, then the fictional general in Doctrinal Publication 6 is right: the best we can do is remain flexible.

The battlefield is made up of a variety of components that interact with each other to form a system. In fact, the battlefield is a system of systems, with complex and dynamic interaction among all components. While this has always been the case with battle, since World War II complexity of this system has dramatically increased. This is not to say the battlefield before World War II was not complex, but with the advent of modern weapons and

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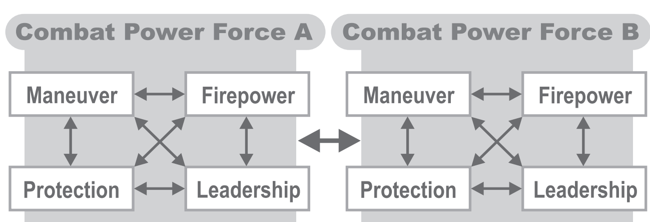
technology, the battlefield has become so complex that the nature of the system itself has changed. As systems increase in complexity, they are more likely to become chaotic. In chaotic systems, small changes can have enormous and surprising effects.

A chaotic system results from the interaction of subsystems that vary nonlinearly. In such systems, the subsystems are coupled, which means that the state of any particular subsystem affects the state of the other subsystems.[5] Since the values that describe the subsystems vary in an irregular way, the state of the system itself varies irregularly. When three or more such subsystems comprise the larger system, the state of the larger system becomes much more sensitive to small disturbances. In fact, the more subsystems there are and the more coupling between them, the more likely chaos is.[6] Likewise, the modern battlefield, comprised of so many related systems, can be chaotic.[7]

The state of a battle at any given time is determined by the interaction of the combat power of the two opposing forces.[8] Combat power is the dynamic interaction of maneuver, firepower, protection and leadership.[9] Considering the battlefield as a system means treating combat power of the two opposing forces as subsystems and the elements that comprise them as additional subsystems. These additional subsystems are further comprised of more subsystems.[10] All of these subsystems interact in such a way that each subsystem's state affects the state of all the other subsystems. Since the state of the larger subsystem, combat power, also affects the state of the opposing force's combat power, the fluctuations of the additional subsystems of one force are coupled to the state of additional subsystems of the opposing force. In this way, a fluctuation in one side's leadership, for example, can have an affect on the other side's protection and vice versa. We can visualize these relationships as illustrated below.



The Battlefield System

Since the beginning of World War II, many elements have been added to these subsystems that make their interactions significantly more complex than in previous wars. Technological developments and doctrinal advancements in strategic and tactical air power, armor detection devices such as infrared and thermal sights, and the dramatic advancements in electronic warfare and information technology have drastically changed the nature of the elements of combat power and how they interact with each other. Furthermore, faster interactions based on the maneuver speed and information flow have made the system much more dynamic. Combined, these developments have made it much more likely that small fluctuations in the system will have dramatic consequences for the overall state of the system—the hallmark of chaotic systems.

The modern battlefield will not always exhibit chaotic behavior, but these developments make it more likely. The Western Front in World War I was a much less complex system than its World War II counterpart. When forces engaged, they quickly reached equilibrium. If one force was far superior to the other, equilibrium would return through the quick defeat of the smaller force. If the forces were evenly matched, the equilibrium would surface in a stalemate. The exasperating years of stagnant trench warfare marked a stable battlefield.

In effect, the Western Front in World War I had reached an equilibrium in which forces tended to cancel out one another. In such a system, the only way to effect change is to apply enormous amounts of force. Indeed, to finally break the stalemate the Allies applied massive combat power at a time when the Germans had exhausted their own.[12] In World War II, however, when weapons, doctrine and transportation were considerably more developed, the battlefield was a much less stable place and defied World War I's infamous stagnation.

The increase in complexity of the World War II battlefield not only defied stagnation; it also yielded many surprises, beginning with the French army's rapid destruction in May and June 1940. In both numbers and quality, the Germans approximately equaled the French

German soldiers examine the remains of a French armored formation, 1940.

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A small fluctuation in leadership dramatically affected fire support, which then greatly affected maneuver. Moreover, since negative effects on one side's system correspond to positive effects for the other side, this small ripple in one side's leadership ended up having a dramatic, positive effect on the other side's maneuver. Because of the increased complexity of the system, a message to a lieutenant colonel and a telephone call from a captain, the Germans were able to penetrate several kilometers behind the French lines in one night.

and a small British Expeditionary Force.[13] In fact, the French and British tanks, while a little slower, were more powerful and better armed than their German counterparts. The Germans did have more aircraft than the Allies, but not great enough to account for the rapid and total German victory.[14] Given that the French and British had the advantage of the defender, their defeat should not have been so quick.

Rather than relying on overwhelming force, which they did not have, the Germans introduced instability in the system in a way for which the Allies were unprepared. By attacking in unexpected locations and using tanks and aircraft in ways the Allies did not anticipate, the Germans introduced instability in the system and turned small, tactical successes into larger, strategic ones. The Allies, relying heavily on fortifications and slow-moving but powerful formations, were unable to react quickly enough to stem the German advance. Fast-moving armored and motorized units supplemented by the devastating effects of Stuka dive-bombers—which often served as artillery—quickly overwhelmed the Allies.

By destabilizing the system in such a way, the Germans took advantage of small changes in the system. In fact, the breakthrough near Sedan on 13 May 1940 is a good example of the dramatic effects of small change and the exploits of an opportunistic enemy. At 6:15 pm on 13 May, a French artillery battalion commander received a message that German tanks were nearby and that his battalion should move. Fifteen minutes later, one of his battery commanders reported small arms coming from German tanks. As things turned out, the messenger was a spy, and the battery commander was mistaken about the presence of tanks as well as the severity of the small arms fire. It is also not clear whether the small arms fire actually came from Germans, since their records do not report any of their units near that area at that time.

Nonetheless, the damage was done. Because of this faulty information, the battalion commander asked for and received permission to move his command post. This premature move had a ripple effect among other artillery units, and by 8:00 pm an entire division's worth of artillery was in full retreat. This evacuation left the entire French 55th Infantry Division without artillery support and made German penetration at Sedan relatively easy. Within hours, the Germans were 10 kilometers behind French lines. This modest gain set the stage for further gains that eventually caused the French and British armies' rapid destruction and the fall of France.[15]

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Significance of Increased Complexity

This increase in complexity requires us to think of surprise in a different way. Current doctrine describes surprise simply as finding the enemy in a place or at a time for which he is unprepared.[16] Thus, *While reliance on technology may provide more information, it also makes the system more complex. By making the system more complex, it makes the system more chaotic. By making the system more chaotic, these new technologies make what happens in the system more unpredictable.*

the only way to avoid surprise to know always where the enemy is. In fact, much of the technology associated with Force XXI is designed to increase the commander's ability to locate the enemy. Satellite imaging, thermal and light amplification devices, and rapid data and image transmission all help the commander visualize the battlefield.

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Although it is impossible to predict the state of a chaotic system at any future time, useful strategies can make the inherent instability of the system work in our favor. First, it is important to understand the system as completely as possible—not for predictive power, but to plan better for contingencies. What happened to the French in 1940 underscores the need for contingency planning. On a battlefield where small changes can have dramatic and unpredictable effects, commanders must remain flexible, ideally with fully resourced contingency plans that account for enemy responses and effects throughout the system. Contingency plans are therefore important for maneuver and support units at all levels.

Second, the inferior force may benefit more from destabilizing the system. In France in 1940, a message to one relatively low-ranking commander profoundly affected the defense of an entire nation. By being prepared to exploit such an effect, the Germans turned what should have been a long campaign into a quick victory. Presumably, even a seemingly minor capability to restrict or alter information flow across echelons of command (whether by deception, jamming or destruction of communication facilities) could give an enemy, no matter how weak militarily, great advantage. If nothing else, this uncertain dynamic underscores the need to take information warfare seriously at all levels. In fact, on the chaotic battlefield, no advantage—enemy or friendly—is unimportant.

This analysis, while incomplete, does suggest that battlefield's increased complexity is an important development that military leaders and planners need to account for as they develop the systems and doctrines to fight the next war. Yet as they add new systems, the battlefield becomes more complex and more unpredictable. Nonetheless, military leaders and planners can use an understanding of the battlefield as a chaotic system to develop strategies, doctrines and courses of action that more effectively handle this increased complexity. Recently, Slobodan Milosevic dramatically resisted American foreign policy goals, despite the overwhelming political and military force arrayed against him. Judging from the news reports, his resilience surprised the United States and its allies. Understanding the battlefield as a chaotic system can account for such possibilities and suggest ways to prepare for and manage the uncertainty of modern war. ***MR***

NOTES

1. See referenced website at <http://www.mnsinc.com/cbassfrd/CWZHOME/Complex/PropBibl.htm>.
2. US Marine Corps Doctrinal Publication 6, *Command and Control* (Headquarters, US Marine Corps, 4 October 1996).
3. Ibid., 23.
4. James Gleick, *Chaos: Making a New Science*, (New York: Penguin Books, 1988), 11-31. Gleick shows that even when weather forecasters could accurately model a weather system, they still could not predict the outcomes of that system.
5. Stephen H. Kellert, *In the Wake of Chaos* (Chicago, IL: University of Chicago Press, 1993), 5
6. David Ruelle, *Chance and Chaos* (Princeton, New Jersey: Princeton University Press, 1991), 81.
7. The conditions for chaos do not necessarily produce a chaotic system. In large systems, for example, irregularities in the subsystems may cancel each other out in a "smoothing effect." For example, one or two stocks fluctuating wildly will not usually, by themselves have a dramatic impact on the stock market, though the stock market does have the characteristics of a chaotic system. Stability in a system that has chaotic characteristics is evidence that this effect is occurring. Since we do not generally observe this stability on the battlefield, it seems safe to conclude in many, if not most circumstances, that the battlefield is indeed chaotic. I am grateful to LTC Phil Beaver of the Department of Math, US Military Academy, for this insight.
8. This section offers a broad-brush, qualitative description of the battlefield as a system. While it is useful to describe the battlefield system quantitatively (showing the relationships of the different elements using mathematical equations) and in more detail, this qualitative description sufficiently establishes the likelihood that the battlefield is a chaotic system.
9. US Army Field Manual (FM) 100-5, *Operations* (Washington, D.C.: Government Printing Office [GPO], 14 June 1993), 2-10.
10. These additional subsystems include the weapons, equipment and organizations that make up the fighting force under consideration.
11. This two-dimensional representation obscures the fact that subsystems of one force can directly and indirectly affect subsystems of the other force.
12. William R. Griffiths, *The Great War*, The West Point Military History Series, Thomas Greiss, ed. (New Jersey: Avery Publishing Group, 1986), Chapter 9.
13. Larry H. Addington, *The Patterns of War since the Eighteenth Century* 2d ed. (Bloomington, IN: Indiana University Press, 1994), 203-204. The Germans had 2600 tanks and 3700 aircraft organized into 136 Divisions. In contrast, the British and French had 3000 tanks and 1800 aircraft organized into 118 divisions.
14. COL Robert Allan Doughty, *The Breaking Point: Sedan and the Fall of France*, 1940 (Hamden, CT: Archon Books, 1990), 3-4.
15. Ibid., 195-197.
16. FM 100-5, *Operations,* 7-10

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